CHAPTER 11

ARCHITECTURAL ELEMENTS

11-1. Introduction. This chapter defines architectural elements, discusses their participation and importance in relation to the seismic design of the structural system, and prescribes the criteria for their design to resist damage from seismic lateral forces. The fundamental principle and underlying criterion of this chapter are that the design of architectural elements will be such that they will not collapse and cause personal injury due to the accelerations and displacements induced by severe seismic disturbances, and that the architectural elements will withstand more frequent but less severe seismic disturbance without excessive damage and economic loss.

11-2. Definition. Architectural elements are elements such as partitions, stairways, windows, suspended ceilings, parapets, building ornamentations and appendages, and storage racks. They are called architectural because they are not part of the vertical or lateral load carrying systems or the mechanical or electrical systems. Although they are usually shown on the architectural drawings, they often have a structural aspect. The architect will consult with the structural, mechanical, and electrical engineers when dealing with these elements. Examples of architectural elements that have a structural aspect follow.

a. Nonstructural walls. A wall is considered "architectural" or "nonstructural" when it does not participate in the resistance to lateral forces. This is the case if the wall is isolated, i.e., not connected to the structure at the top and the ends, or if it is very flexible relative to the structural wall frames. Note that an isolated wall must be capable of acting as a cantilever from the floor or be braced laterally.

b. Curtain walls and filler walls. A curtain wall is an exterior wall, usually of masonry, that lies outside of, and usually conceals, the structural frame. A filler wall is an infill, usually of masonry, within the members of a frame. These are often considered architectural if they are designed and detailed by the architect, but they can act as structural shear walls. If they are connected to the frame, they will be subjected to the deflections of the frame and will participate with the frame in resisting lateral forces.

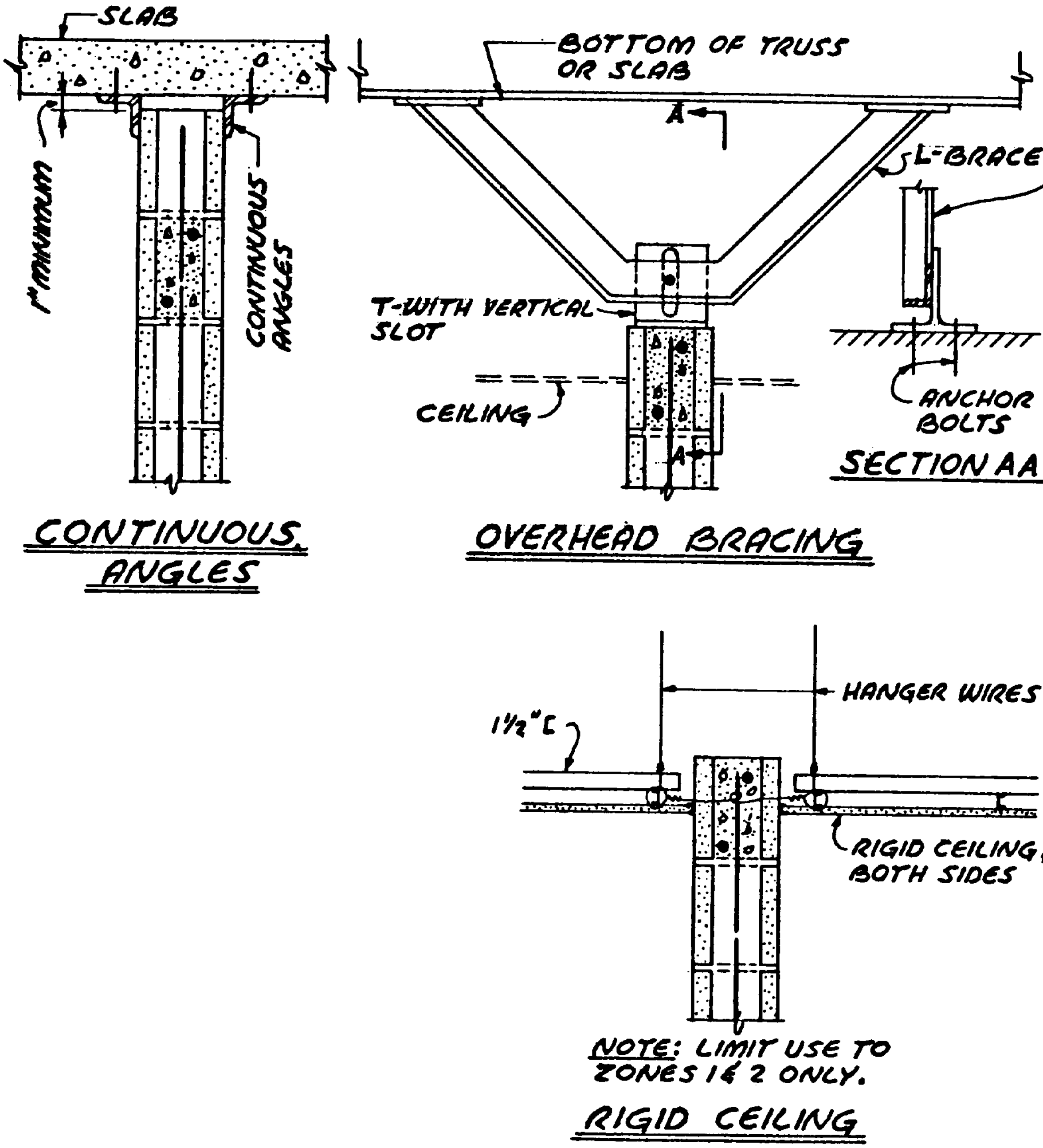
c. Partial infill walls. A partial infill wall is one that has a strip of windows between the top of the solid infill and the bottom of the floor above or has a vertical strip of window between the one or both ends of the infill and a column. Such walls require special treatment: if they are not properly isolated from the structural system they will act as shear walls. The wall with windows along the top is of particular concern because of its potential effect on the adjacent columns. The columns are fully braced where there is an adjacent infill but is unbraced in the zone between the windows. The upper, unbraced part of the column is a "short column," and its greater rigidity (compared with other unbraced columns in the system) must be accounted for in the design.

d. Precast panels. Exterior walls that have precast panels attached to the frame are a special case. The general design of the walls is usually shown on the architectural drawings, while the structural details of the panels are usually shown on the structural drawings. Often the structural design is assigned to the General Contractor so as to allow maximum use of the special expertise of the selected panel subcontractor. In such cases, the structural drawings will include design criteria and representative details in order to show what is expected. The design criteria will include the required design forces and the frame deflections that must be accommodated by the panels and their connections.

11-3. Design criteria. An architectural element must safely resist horizontal forces equal to the quantity ZI_pC_p times its own weight, W_p, and must be capable of conforming (accommodating) to the lateral deflections that it will be subjected to during the lateral deformation of the building.

a. Lateral forces. The equivalent static lateral force that is applied to architectural elements is given by SEAOC equation 1-10, with C_p values given in SEAOC Table 1-H. In general, the value of C_p is 0.75; however, for ornamentation, parapets, and other appendages, where the potential for collapse and injury is greater, C_p is 2.0. For exterior wall panels, C_p is 0.75; however, the special provisions of SEAOC 1H2d(2) apply.

b. Deflections. For the design of the structure, lateral deflections or drift of a story relative to its adjacent story is not to exceed $0.04/R_w$ nor 0.005 times the story height for buildings having a period of less than 0.7 second, and $0.03/R_w$ nor 0.004 times the story height for buildings having a period of 0.7 second or greater unless it can be demonstrated that greater drift can be tolerated



Lateral Supports - Nonstructural Partition

Figure 11-1. Typical details of isolation of walls.

(SEAOC 1E8). The deformation is calculated from the application of the required lateral forces as discussed in chapter 4.

(1) Architectural elements will be designed and detailed to conform to the structural deformations without damage.

(2) Exterior elements are required to allow for relative movement equal to $3R_w/8$ times the calculated elastic story displacement caused by required seismic forces or ½ inch per story, whichever is greater (SEAOC 1H2d(2)).

(3) The effects of adjoining rigid elements on the structural system will also be investigated (SEAOC 1H2d(1)).

11-4. Detailed requirements.

a. Partitions. Partitions are classified into two general categories: rigid and nonrigid. Reference is also made to chapter 6, paragraph 6-6.

(1) *Rigid partitions.* This category generally refers to nonstructural masonry walls. Walls will be isolated where they are unable to resist in-plane

lateral forces to which they are subjected, based on relative rigidities. Typical details for isolation of these walls are shown in figure 11-1. These walls will be designed for the prescribed forces normal to their plane.

(2) *Nonrigid partitions*. This category generally refers to nonstructural partitions such as stud and drywall, stud and plaster, and movable partitions. When constructed according to standard recommended practice, it is assumed that the partitions can withstand the design in-plane drift of 0.005 times the story height (i.e., 1/16 inch per foot of height) without damage. Therefore, if the structure is designed to control drift within the prescribed limits, these partitions do not require special isolation details. They will be designed for the prescribed seismic force acting normal to flat surfaces. However, wind or the usual 5 pounds per square foot partition load will usually govern. If the structural design drift is not controlled within the prescribed limits, isolation of partitions will be required for reduction of nonstructural damage. Economic justification between potential damage and costs of isolation will be considered. A decision has to be made for each project as to the role, if any, such partitions will contribute to damping and response of the structure, and the effect of seismic forces parallel to the partition resulting from the structural system as a whole. Usually, it may be assumed that this type of partition is subject to future alterations in layout location. The structural role of partitions may be controlled by height of partitions and methods of support.

b. Veneered walls. There are two methods for attaching veneer to a backup structural wall (see fig 11-2).

(1) Anchored veneer is a masonry facing secured by joint reinforcement or equivalent mechanical tie attached to the backup. All required load-carrying capacity (both vertical and lateral) will be provided by the structural backup wall. The veneer will be nonbearing and isolated on three edges to preclude it from resisting any load other than its own weight, and in no case shall it be considered part of the wall in computing the required thickness of a masonry wall. The veneer will be not less than 1½ inches nor more than 5 inches thick. The veneer will be tied to the structural wall with joint reinforcement or $^{3}/_{16}$-inch round corrosion resisting metal ties capable of resisting in tension or compression the wind load or two times the weight of veneer, whichever governs. Maximum spacing of ties is 16 inches, and a tie must be provided for each 2 square feet of wall area. Adjustable ties are not permitted in Seismic Zones 3 and 4. They may be used in Zones 1 and 2 if the basic wind speed is less than 100 mph. If adjustable ties are used, they will be the double pintle-eye type, with the minimum wire size being $^{3}/_{16}$ inch; play within the pintle will be limited to $^{1}/_{16}$ inch, and the maximum vertical eccentricity will not exceed ½ inch. The maximum space between the veneer and the backing will not exceed 3 inches unless spot mortar bedding is provided to stiffen the ties. A noncombustible, noncorrosive horizontal structural framing will be provided for vertical support of the veneer. The maximum vertical distance between horizontal supports will not exceed 25 feet above the adjacent ground and 12 feet maximum spacing above the 25-foot height.

(2) Adhered veneer is masonry veneer attached to the backing with minimum 3/8 inch to maximum ¾ inch mortar or with approved thin set latex Portland cement mortar. The bond of the mortar to the supporting element will be capable of withstanding a shear stress of 50 psi. Maximum thickness of the veneer will be limited to 1 inch. Since adhered veneer is supported through adhesion to the mortar applied over a backup, consideration will be given for differential movement of supports, including that caused by temperature, shrinkage, creep, and deflection. A horizontal expansion joint in the veneer is recommended at each floor level to prevent spalling. Vertical control joints should be provided in the veneer at each control joint in the backup.

c. Connections of exterior wall panels. Precast, nonbearing, nonshear wall panels or other elements that are attached to or enclose the exterior will be designed and detailed to accommodate movements of the structure resulting from lateral forces or temperature changes. The concrete panels or other elements will be supported by means of cast-in-place concrete or by mechanical devices. Connections and panel joints will be designed to allow for the relative movement between stories and will be designed for the forces specified in SEAOC 1H2d(2). Connections will have sufficient ductility and rotation capacity so as to preclude fracture of the concrete or brittle failures at or near welds. Inserts in concrete shall be attached to or hooked around reinforcing steel or otherwise terminated so as to effectively transfer forces to the reinforcing steel. Connections to permit movement in the plane of the panel for story drift may be properly designed sliding connections using slotted or oversize holes, or may be connections that permit movement by bending of steel components without failure. Typical design forces are shown in figure 11-3.

d. Suspended ceiling systems. Seismic design is required in Zones 2, 3, and 4. Earthquake damage to suspended ceiling systems can be limited by

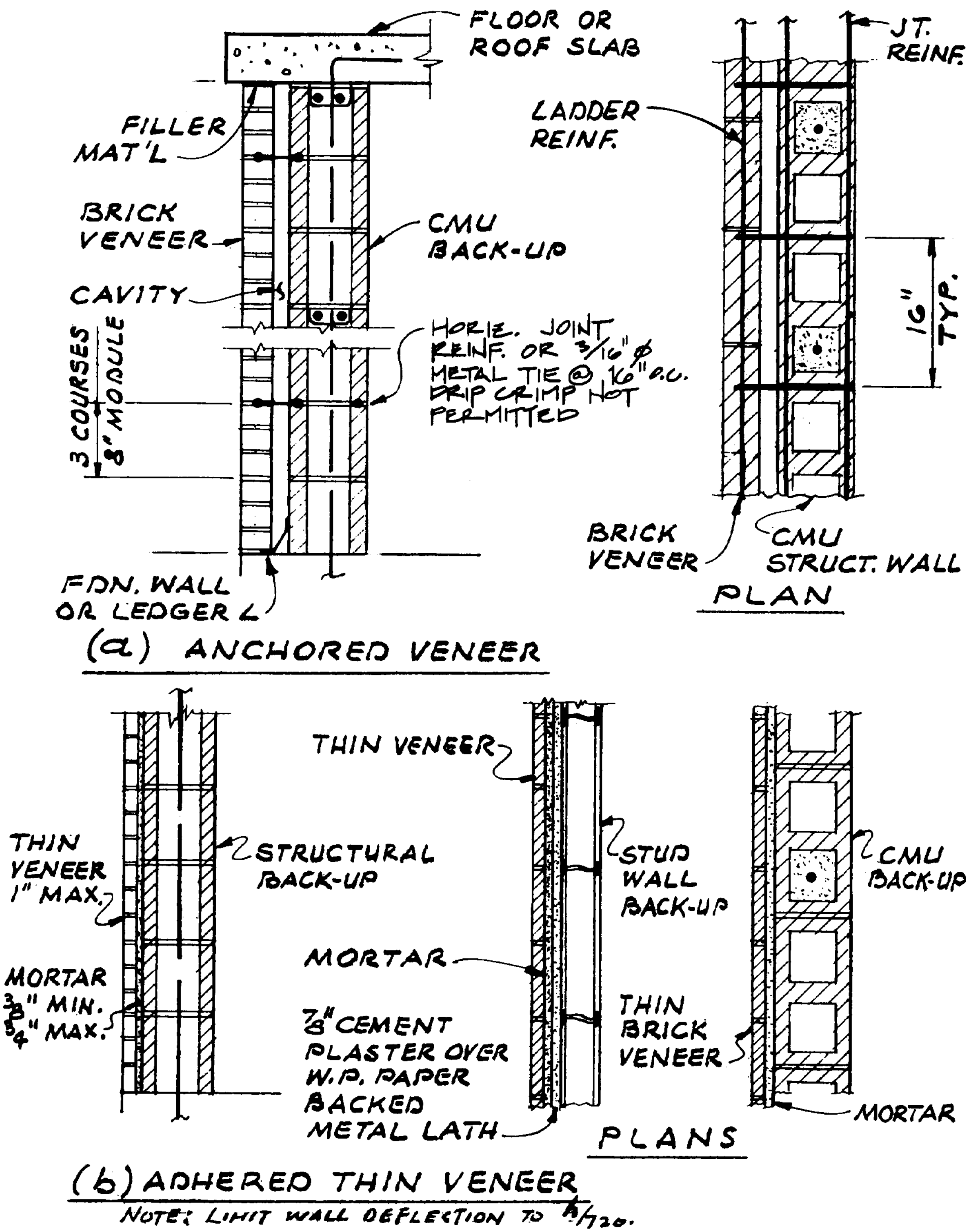
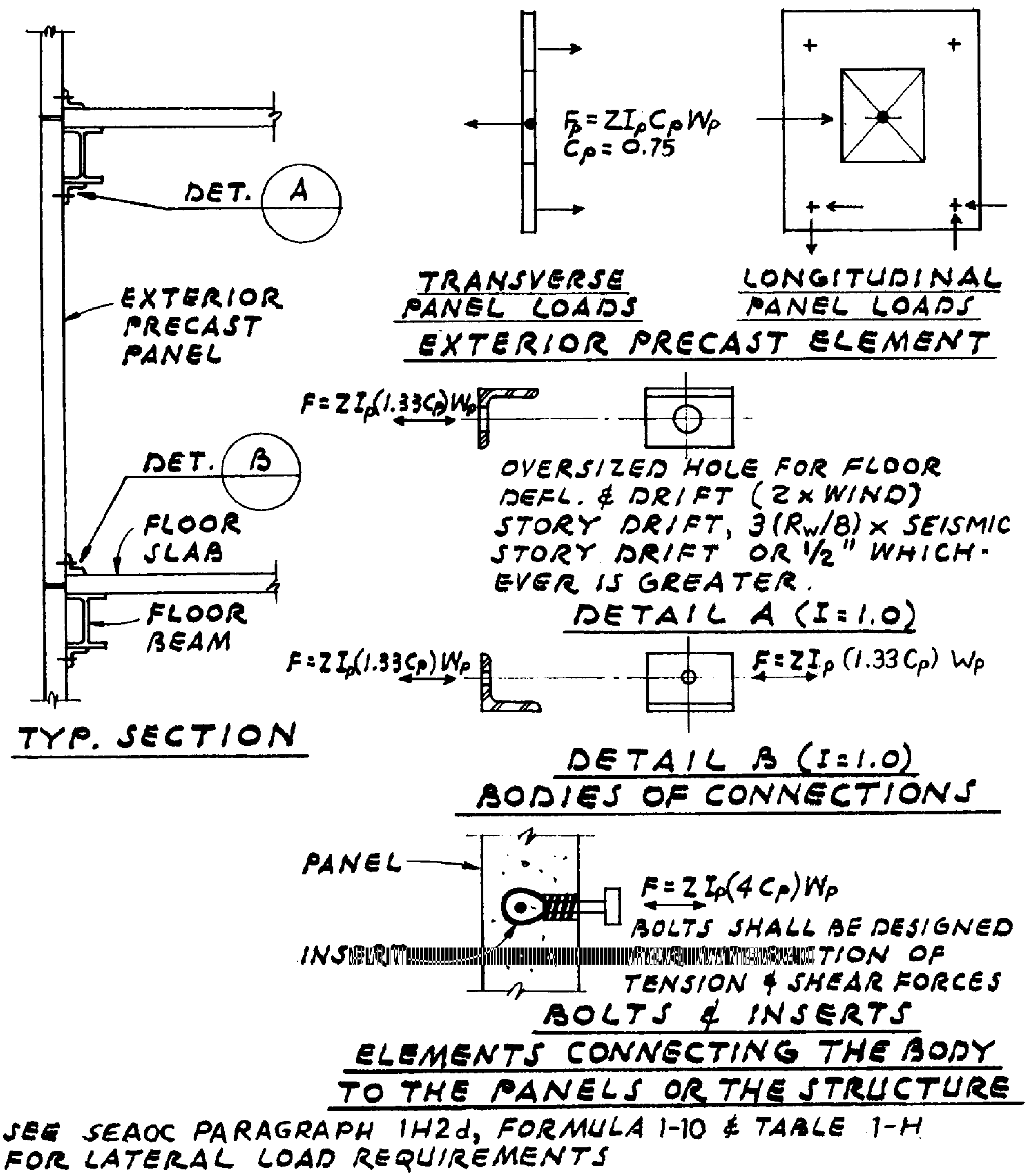


Figure 11-2. Veneered walls.

proper support and detailing. Suspended ceiling framing systems will be designed for forces prescribed in SEAOC Table 1-H. The ceiling weight, will include all light fixtures and other equipment laterally supported by the ceiling. For purposes of determining the lateral force, a ceiling weight of not less than 4 pounds per square foot will be used. The support of the ceiling systems will be by positive means such as wire or an approved seismic clip system. Typical details of suspended acoustical tile ceilings are shown in figure 11-4.



e. Parapets, ornamentation, and appendages. These elements will be designed for forces resulting from C_p equal to 2.0 as prescribed in SEAOC 1G and Table 1-H. For the design of parapets, refer to chapter 6, paragraph 6-6c.

f. Window frames. Window frames will be designed to accommodate deflections of the structure without imposing a load on the glass. As glass is a brittle material, a considerable hazard of falling glass may be present. It is particularly serious if the glass is above and adjacent to a public way. This hazard can be eliminated by proper isolation between glass and its enclosing frame. It is obvious that the magnitude of isolation required depends upon the drift and the size of the individual pane or enclosing frame. Thus a pane of glass in a full-story-height frame should have an isolation or movement capability as great as the maximum possible drift

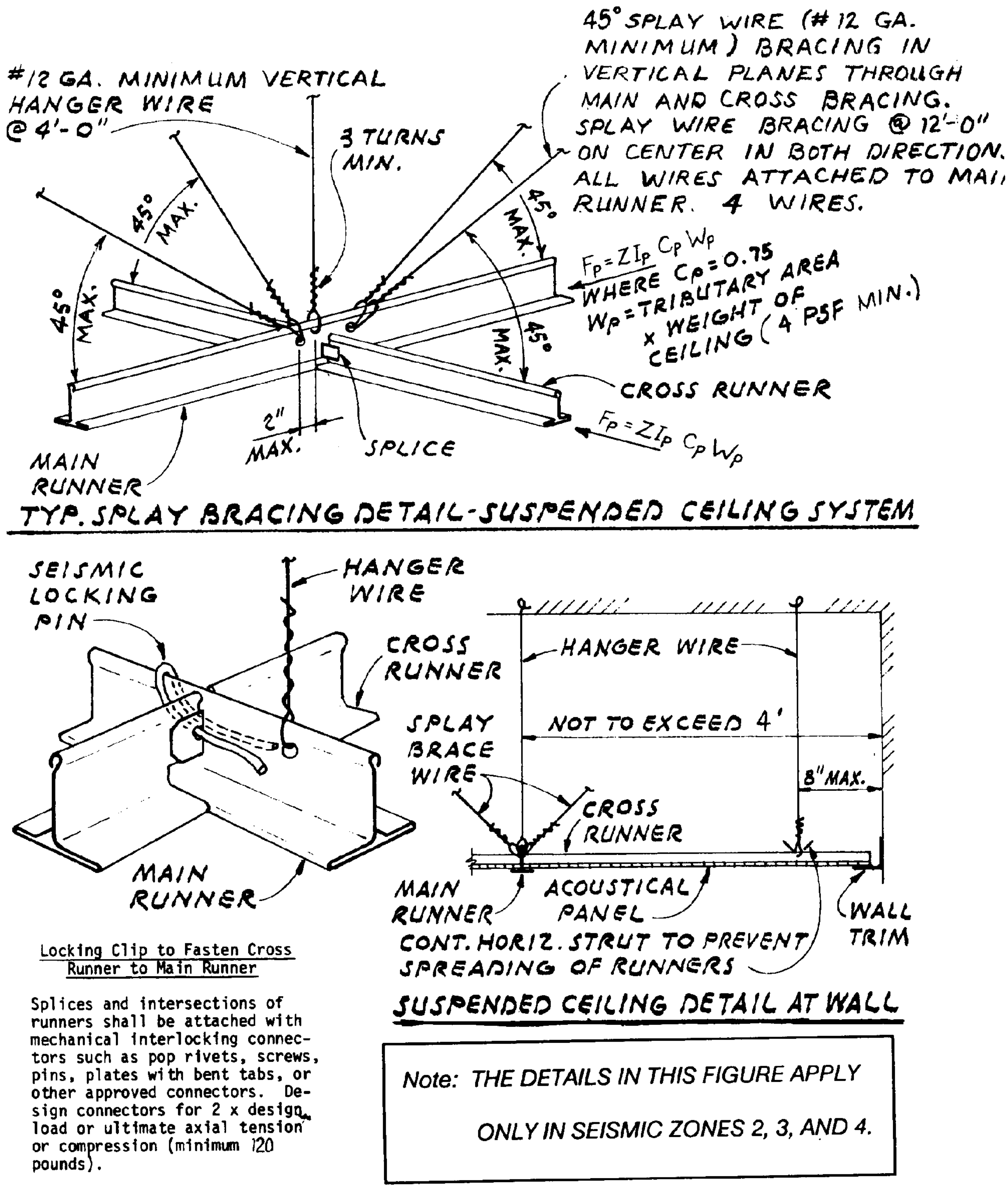


Figure 11-4. Suspended acoustical tile ceiling.

(e.g., $3R_w/8$ times the calculated elastic story displacement prescribed in SEAOC 1H2d). The actual isolation clearance will depend on the geometry and deformation characteristics of enclosing frame, frame support, and structural system. Special care will be exercised in the field to see that such isolation is actually obtained.

g. Stairways. Stairways tend to act like struts; therefore, the rigidity of the stairway, relative to the structure, will be considered. In some cases the stairway will be isolated in order to prevent damage to itself by the building frame, or to prevent the stair from imposing an unwanted constraint on the frame.

h. Storage racks.

(1) Storage racks supported at grade will be treated as equipment on the ground according to chapter 12, paragraph 12-5, with W_p equal to the weight of the rack plus its contents.

(a) Rigid racks. Racks having a period of vibration less than 0.06 second will be governed by equation 12-3, with $C_p = 0.75$, as given in SEAOC Table 1-H; thus, $F_p = 0.5\ ZI_pC_pW_p$.

(b) Flexible racks. Racks having a period of vibration greater than 0.06 second will be treated as nonbuilding structures as prescribed in Chapter 13. The minimum lateral force is obtained from SEAOC equation 1-1, with $R_w = 5$, as given in SEAOC Table 1-I; thus, $V = 0.20\ ZICW$. The value of C used for design will not be less than 2.5.

(2) Storage racks supported above grade will be designed to chapter 12, paragraph 12-3 if rigid or paragraph 12-4 if nonrigid.

11-5. Alternative designs. Where an accepted national standard or approved test data provide the basis for earthquake resistance of a particular type of architectural element or rack, such standard or data may be accepted as a basis for design under certain limitations. (See SEAOC 1G5.)